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THE DISTRIBUTION OF ANTHRAX, ITS EPIDEMIOLOGICAL PECULIARITIES AND THE ORGANIZATION OF THE CAMPAIGN AGAINST IT IN COUNTRIES OUTSIDE THE SOVIET UNION*†

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MORE than a hundred years have passed since the anthrax organism was found in the blood of sick animals and the Russian scientist F. Brauell' discovered the aetiological importance of this observation. Research workers (both medical and veterinary) have worked unceasingly since this discovery on the epizootology, epidemiology, bacteriology, immunology, treatment and prevention of this disease, which affects both agricultural livestock and human beings. In spite of the progress which has been made in this direction cases are recorded nowadays in all five continents in almost every country in the world.

* Read on 1 February 1957 at the Inter-Institute Conference on problems of the focal occurrence and epidemiology of particularly dangerous infections, at Saratov.

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This affects not only those countries with a developed cattle-breeding industry and local plant for processing the raw products of this industry, but it also affects the countries which process raw and part-processed animal products imported from the first group of countries.

The principal reason for the widespread and persistent occurrence of anthrax in various countries is the well-known spore-forming ability of the organism; these spores are capable of survival for extraordinarily long periods. Once an area is contaminated by anthrax bacilli it remains an epizootic focus for an indefinite period, since the various steps taken to decontaminate the ground are not as yet effective enough.

The incidence of anthrax among human beings in various countries outside the Soviet Union is shown in Table 1; it is based on the UNO World Health Organization's figures for 1950–52. The highest incidence in Europe is in Portugal (2·16), Spain (0·46), Italy (0·26), Greece (0·23), and so on. The lowest incidence is observed in Belgium, France, Finland, Great Britain, Austria and the U.S.S.R.

TABLE 1. THE RECORDED INCIDENCE OF ANTHRAX AMONG HUMAN BEINGS IN VARIOUS COUNTRIES (1950–1952)*

Country	Number of cases			Average per 10,000 of the population
	1950	1951	1952	
Portugal (the parent state)	2270	1697	1280	2·16
Spain	1721	1312	887	0·46
Italy	1239	1058	1364	0·26
Greece	242	135	164	0·23
Federal German Republic	20	25	20	0·0043
Belgium	3	8	8	0·07
U.S.A.	49	60	47	0·003
Mexico	161	172	114	0·37
Chile	336	223	335	0·5
Venezuela	238	135	135	0·34
Uruguay	68	61	89	0·03
Paraguay	83	31	No figures	0·4
Guatemala	23	38	31	0·36
Salvador	17	17	6	0·07
Ecuador	10	5	30	0·1
Argentina	No figures	110	460	0·7
Peru	No figures	33	38	0·03
Turkey	1547	1329	1668	0·71
Iraq	134	281	281	0·43
Ceylon	No figures	270	3	0·11
Vietnam	No figures	No figures	24	0·009
Cape Verde Islands	32	63	86	4·33
Tanganyika	396	368	218	0·46
Ruanda-Urundi	193	224	969	0·41
Portuguese New Guinea	11	10	6	0·14
Kenya	756	643	346	0·12
Spanish Morocco	11	11	2	0·073
French West Africa	430	324	No figures	0·2
Sudan	19	93	No figures	0·16
Union of South Africa	No figures	36	26	0·12
Uganda	No figures	No figures	123	0·2
Australia	2	No figures	No figures	0·004
New Hebrides	10	No figures	No figures	2
Papua and New Guinea	3	No figures	3	0·006

* Based on figures of the United Nations World Health Organization.

In Europe the southern states and the so-called Mediterranean countries where there is extensive cattle-breeding are principally affected.

In North America, Mexico and the United States are most affected; in Mexico from 100 to 170 human cases are recorded annually, and 50–60 cases in the United States.

According to the official figures the highest incidence in South America occurs in Chile, where about 300 cases, amounting to 0·5 per 1000 of the population, are recorded annually. However, the official figures do not correspond with private observations made by individual scientists. A survey of the Chilean hospitals by Morosler, Solar and Sosa indicated that 717 anthrax patients were admitted to hospital in 1950. In Chile anthrax occurs more often than brucellosis, dysentery and even more frequently than pertussis and diphtheria. The next highest incidence is in Paraguay (0·4), Venezuela (0·34), Argentina (0·17), Ecuador (0·1), and so on.

Guatemala has the highest incidence in the Central American states, and in America incidence is thus at its highest in countries with a highly developed cattle-breeding industry.

Anthrax is widely distributed throughout Asia. In Turkey, for example, 1500 and more human cases are recorded annually. According to the official figures 4544 cases were recorded in 1950–52, which is a yearly average of 0·7 for every 10,000 of the population. A considerable number of anthrax cases is recorded in Iraq (0·43), Ceylon and a number of countries in Western Asia (Aden, Jordan, Saudi Arabia, etc.).

The U.N. World Health Organization states that in Africa in 1950–52 a high incidence was recorded in the Cape Verde Islands (4·53); incidence was considerably lower in Tanganyika (0·46), Ruanda-Urundi (0·41), Portuguese Guinea (0·14), Kenya (0·12), and so on.

However, the authors of *Global Epidemiology* (Simmons, Wain, Anderson and others) state that the recording of cases in Africa is inaccurate, as it is in Asia. There is a high incidence among human beings in Oceania, in the New Hebrides (2). As was the case with Chile, the World Health Organization's figures often disagree with the special statistical surveys made by individuals; as a rule they indicate faulty calculations, and so cannot claim to be exhaustive and reliable. From this we may conclude that world epidemiological statistics on anthrax cannot be in perfect order, and that considerable improvements are essential.

As one might expect, incidence among human beings in countries with a large cattle-breeding industry is directly connected with epizootics.

According to figures published by the International Epizootics Bureau more than 7000 cases among cattle were recorded in 175 districts in Portugal in 1953, in Spain there were 4076 cases in 131 districts, in Greece 1080 villages were affected by anthrax, and 763 foci of this disease were found in Italy; all these figures relate to the year 1953. More than 2000 outbreaks of anthrax are recorded every year in India; in 1953 alone 9628 head of cattle developed the disease in India, and 7616 died as a result of it.

According to Delpy and Kaweh, in Iran one million sheep out of 15 million died of anthrax every year up to very recent times.

As a rule, agricultural livestock are the sources of anthrax infection everywhere, but the dominant species in this respect varies from country to country. For example, Iliev states that in Bulgaria the animals principally affected are sheep, then large domestic ruminants and horses. In Jugoslavia sheep and pigs are affected. In North Africa (Morocco, Egypt) and in some Asian countries (Iran, Turkey, Arabia) the most frequent and typical cases occur among sheep and goats. Cattle and horses are the principal sources of anthrax infection in the Argentine, Mexico, Equatorial and South Africa and India. In the latter countries in particular, there are frequent outbreaks among water buffaloes, etc. For many years cattle were the animals principally affected

in the U.S.A., but in 1951–53 pigs accounted for a considerable proportion of the cases, after a large number of anthrax outbreaks (2360 outbreaks in 38 states); third in order of importance were mink, then only horses and mules, sheep and deer.

During the first eight months of 1953 a total of 184 outbreaks were recorded in the U.S.A.; they affected 310 head of cattle, 111 pigs, 86 mink, 51 sheep and 8 horses. Veterinary workers estimated that 41 per cent of the outbreaks were caused by foodstuffs, especially bone meal, contaminated by anthrax spores, 20 per cent by infected ground, 20 arose after injections of defective vaccine, and the causes of the remainder were unknown. The American workers Hell, Stein and Smith have devoted a great deal of study to the epizootic situation which obtained in the U.S.A. in 1952, when 1642 outbreaks were recorded in 432 districts in 32 states. In the course of these outbreaks 3451 animals died, and this was the highest number of outbreaks ever recorded in one year. The situation arose due to infection in herds of hogs in Illinois, Indiana, Iowa, Michigan and Ohio during the first six months of the year. When an investigation into the outbreaks were carried out in the Middle West of the U.S.A. it became apparent that almost all the outbreaks were of alimentary origin. In Ohio, for example, the anthrax bacillus was isolated from raw bone meal which was being fed to pigs. This meal was imported from Belgium (it came apparently from the Belgian Congo).

According to Stein the characteristics of these outbreaks among hogs were in general as follows: they were very widespread, arose in winter in areas where there had been previous cases, the incidence and mortality were low and there were no recurring cases among hogs or other animals kept in close proximity to the hogs. Incidence among farm-bred mink is the second interesting feature of the principal animal sources of anthrax in the U.S.A.; it also occurs in other western countries. Published veterinary statistics mention cases among mink every year; similar epizootics in France were described by Paillé in 1948. Consumption of infected food caused these cases.

In addition to the animal sources of anthrax huge soil foci continue to exist in many countries; these are areas which became contaminated by anthrax spores many years ago. The "accursed fields" of La Beauce in France (now the Department d'Eure et Loire) have been well known for many years; the shepherds, filled with terror by this devastating disease, fled from La Beauce into the marshy regions of Solonne, so creating new foci of infection there. In Jugoslavia certain pastures in the Chernogora district and in Serbia are extremely dangerous, as is the Nene valley in Northamptonshire, England, the San Joaquin and Sacramento valleys in California, pastures in South Dakota, the shores of the Gulf of Mexico and the valleys of the Mississippi and Missouri in the United States.

When the rivers flood, organisms from the surface of these soil foci are spread over a wide area, increasing the range of the infection. Depending on the conditions of infection, anthrax in human beings may be occupational (developed as a result of industrial or agricultural work) and non-occupational (chance infection, or infection due to certain conditions in everyday life).

Occupational agricultural anthrax is a result of infection either from animals or from the soil.

In capitalist countries the desire in agriculture to make good losses due to an animal's death leads to failure to observe elementary precautions and to cases of anthrax among human beings. A low level of personal hygiene and lack of medical knowledge contributes to this state of affairs among the peasants in countries with outdated social systems.

Cases arise as a result of looking after sick animals, skinning the carcases, handling animal raw material, burying or using the bodies of animals which died of the disease, and in other ways. In African countries (Mozambique, Angola, the Union of South Africa, Kenya, Rhodesia, Tanganyika) the most frequent cause of large-scale outbreaks

of anthrax is, according to Simmons, Wain and others and also Curasson, the consumption of the bodies of animals which died of the disease.

It is also necessary to classify with cases occurring in agriculture those which arise due to peasants' processing hides by hand, and also those cases connected with drying and crushing bones to make bone meal (England, Belgium and other countries).

First in the category of occupational industrial anthrax come those cases which arise as a result of handling infected wood, hair, hides and skins.

In some countries, for example the United States, which are large-scale consumers of the raw materials mentioned, industrial anthrax shows a marked tendency to increase. According to Lloyd, Stein, Wolff and Heimann, in the period 1934–49 total of 1120 cases of anthrax were classifiable as follows: 735 (70 per cent) were connected with the animal, textile, etc. industries, 192 (17 per cent) with agriculture, 31 (about 3 per cent) were chance cases or due to living conditions, and 162 (10·5 per cent) were due to unclassifiable circumstances.

However, if the parallel evolution of agricultural and industrial anthrax in the United States is traced for a period of 31 years, i.e. from 1919 to 1949, taking the total number of cases at ten year periods, we see such a picture as appears in Table 2.

TABLE 2. INCIDENCE OF ANTHRAX (PERCENTAGE) IN CONNEXION WITH THE CONDITIONS UNDER WHICH THE DISEASE IS CONTRACTED

Anthrax group classification	1919–28	1929–38	1939–[illegible]
Industrial	53·5	50	80
Agricultural	21	33·5	14·5
Non-occupational	19·5	16·5	5·5
Total	100	100	100

Ninety-nine per cent of all the industrial anthrax cases in the U.S.A. are concentrated in New England and the middle of the Atlantic seaboard, in the states of Pennsylvania, New York, New Jersey, Massachusetts, New Hampshire, Delaware and Connecticut. This can be simply explained, since 80 per cent of the tanning and wool- and hair-processing industry of the United States is concentrated in this area. In contrast to this, agricultural anthrax, as we have already mentioned, occurs mainly in the states of Louisiana, California, Texas, Missouri, Mississippi, South Dakota and Arkansas, where there are the greatest cattle-breeding districts.

If the development of industrial anthrax in the U.S.A. is traced over the period 1919–49 with reference to the nature of the raw material treated, the following series of figures is obtained: hides and skins in 1919–28 caused 64·5 per cent, in 1929–38 56 per cent, and in 1939–49 18 per cent of cases. The figures for wool and hair for the corresponding times are 35, 5, 44 and 82 per cent.

It follows from the findings tabulated above that industrial anthrax in the U.S.A. is increasing steadily; it is now far more common than agricultural anthrax and exceeds the total of chance and similar cases by an even greater margin. In its turn industrial anthrax is becoming more closely connected with the processing of wool and hair, and in particular with that imported from Western Asia and Southern Europe (Greece, Italy, Portugal, Spain, Cyprus, Malta, etc.).

In the United States those who develop the disease most often are those who work in factories making woollen carpets and shawls, on the pre-spinning and spinning processes (90·2 per cent); dyers contract the disease much more rarely (4·1 per cent).

and the percentage of incidence is also small among other classes of worker in these industries.

The increase in the proportion of industrial anthrax connected with processing hair and wool is also dependent upon the fact that the carpet and textile industry has developed more than the tanning industry. Whereas the United States imported 320 million lb of hides and skins in 1919, the quantity had decreased to 160 million lb by 1949, whereas imports of carpet and textile wool had increased from 330 million lb in 1919 to 490 million lb, and imports of mohair over the corresponding period had increased from 8 million lb to 17 million lb in 1949. When an epidemiological analysis was made it became apparent that the majority of the cases considered (95 per cent) came from handling goatskins imported from India, Pakistan and China. The percentages of infection from hair and wool were 24 and 76 respectively.

Of 82 cases analysed in which persons had become infected from hair, 74 were due to mohair, 5 to horse-hair and 3 to hair from other sources (i.e. from cattle, camels and pigs).

It was clear that mohair was contaminated to a greater extent than goatskin. The reason for this becomes clear if one considers that the skin of one goat makes up one weight unit (e.g. 2–3 lb), whereas the wool of several goats would be required to make up a similar weight unit; therefore there is more chance of becoming infected from the wool.

Almost all the cases connected with wool-processing occurred in the carpet-weaving industry. The fact is that most of the so-called "degreased" wool obtained from shearings of animals which died of anthrax is taken by these carpet factories, and only a very small proportion of it goes to the textile industry, so if the carpet industry consumed 25,000,000 lb of degreased wool, the textile industry took only 25,000 lb.

We may classify as sporadic those cases which did not arise through the patient's occupation; anthrax contracted as a result of using infected shaving brushes will serve as an example. Such cases were of quite regular occurrence in the U.S.A., England and Japan until the beginning of the nineteen-forties.

In Kenya the natives smear their bodies with animal fat and often become infected with anthrax in this way.

In many countries cases often occur which are due to wearing caps, collars, gloves, scarves and other everyday garments which are contaminated by anthrax spores. Jamison and Green have described cases which occurred among stevedores through carrying bags containing bone meal and organic fertilizers.

Outside the Soviet Union anthrax persists in the agricultural industry, due to the following circumstances: cases among cattle are diagnosed late, raw material is not disinfected before use, animals which have developed the disease are slaughtered and no steps are taken to deal with infected soil; in industry generally its development is assisted by processing local and imported animal raw materials, in particular goatskins and mohair.

In the countries where occupational anthrax occurs the incidence reaches its peak at the following seasons: July–September in the northern hemisphere (Spain, Greece, Iraq, Turkey, etc.), and during the first months of the year in the southern hemisphere (Uganda, Chile, Uruguay, etc.). This is directly connected with the seasonal nature of the epizootics. The seasonal frequency of cases in industry depends on the monthly tempo of work in factories processing animal raw material (in U.S.A., England, Belgium, etc.).

Outside the Soviet Union the cutaneous form of anthrax predominates; the intestinal form is met with extremely rarely, and the pneumonic form is even rarer. For example, according to statistics prepared by G. Smith, the well-known American expert on anthrax, 1·7 per cent of cases are internal forms of anthrax, whereas 98·3 per cent of

cases take the cutaneous form. Of 640 cases considered by Smith, only 4 persons developed the primary pneumonic form of anthrax, and only 2 the intestinal form.

A mass outbreak of the intestinal form of anthrax was observed in Haiti in 1943.

Many foreign scientists state that about half of all the cutaneous cases of anthrax show localization on the face, head and neck, which again emphasizes the part played by infected finger nails in scratching the infection into the skin.

In contrast to the situation in Europe, there is a high death rate from anthrax in the U.S.A., in agriculture and due to infection from articles in everyday domestic use. Although the death rate in industry fell from 20 per cent in 1910–20 to 8 per cent in 1939–43, it maintains its high level in agricultural districts in the U.S.A., varying from 20 to 25 per cent.

It is appropriate here to draw an analogy with Olsuf'ev's observations showing that tularaemia and tick-borne rickettsiosis are more virulent on the American continent than in Eurasia (see Zh. mikrobiol., épidemiol. immunobiol. 9, 1956).

American workers connect the high death rate from anthrax in agriculture with the fact that persons suffering from the disease seek medical advice too late and the cases are not diagnosed in time, which leads to great deterioration in the prognosis.

Recommendations for the prevention of anthrax were developed on an international level by a commission of experts from the World Health Organization in co-operation with experts from the United Nations Food and Agriculture Organization; these recommendations were published in 1951.

In accordance with these recommendations, a campaign against anthrax in agriculture provides for early diagnosis of the disease, destruction of infected carcases, cheap or free vaccination of cattle and medical education of the population in the prevention of anthrax.

A process is suggested for industry whereby animal raw materials coming in for processing are decontaminated.

In agriculture foci are principally destroyed by immunizing the cattle with various live vaccines (M. Stern's vaccine in India, Africa, Great Britain and other countries, Nitta and Takashi's vaccine in Japan, and with anthrax bacterins in the U.S.A.). Recently (i.e. in 1954) a chemical vaccine has been developed by Wright and his colleagues, and is being brought into use in the U.S.A.

Much attention is paid in the foreign literature to Max Stern's vaccine, which he developed in the Onderstepoort veterinary institute in the Transvaal. It has been named "vaccine strain 34 F_2". The principle used in preparing the vaccine is to select immunogenic but avirulent R-form strains of anthrax which have been grown in an atmosphere with a high CO_2 content (30–50 per cent). This vaccine was successfully tested in the Union of South Africa, India, Jugoslavia and in other countries.

There is a vaccine in England which is based on a similar idea, but it is suspended in glycerol and saponin and was developed in the veterinary laboratory of the Ministry of Agriculture and Fisheries at Weybridge, Surrey and is officially recognized as conferring immunity to, and preventing, anthrax in agricultural animals.

American research workers (Wright and his colleagues, 1954) prepared a filterable anthrax preventive antigen by cultivating a non-proteolytic and non-encapsulated strain in a synthetic fluid medium. The antigen precipitated with alum has marked prophylactic properties whether used in animals (rabbits, monkeys) or human beings. Human beings are given three subcutaneous injections each of 0·5 ml of the antigen, which gave under experimental conditions a reliable state of immunity. Very recently Boor and Tresselt have prepared a prophylactic antigen by cultivating anthrax bacilli in a complex medium containing serum albumin and yeast extract. Three doses of 10, 20 and 30 mg respectively gave monkeys protection against 20,000–200,000 LD50.

Boor and Tresselt were of opinion that this preparation, with its marked immunogenic properties and with no adverse effects when used in monkeys, made a practical approach to the problem of human immunization possible; such immunization was not possible if attenuated Pasteur-type vaccines were used.

In contrast to the situation obtaining in the Soviet Union other nations devote little research to improving the state of the soil and rendering it biologically free from anthrax.

The Ascoli reaction, together with other methods, is preferred for the diagnosis of anthrax in animals in Europe, whereas in the United States the use of bacteriological methods with subsequent infectivity tests in laboratory animals is preferred.

The Liverpool method of disinfecting wool and hair is used in the majority of countries outside the Soviet Union; besides the pickling method (Schathenfroh) treatment with sulphur dioxide (Robertson) and with tincture of iodine or iodine vapour (Smith) have been suggested as methods of disinfecting hides and skins. MacDonald suggested a solution of formaldehyde for disinfecting carpets during manufacture. The Special United Nations Commission suggests lime-water for disinfecting workshops, etc. Sulphonamides and antibiotics (penicillin, chlortetracycline, chloramphenicol, oxytetracycline) are strongly recommended as effective means of treating anthrax cases, in addition to anthrax antiserum and arsenical preparations. For example, in the United States antibiotics are preferred to antiserum because of its allergenic properties.

There is no large-scale specific prophylaxis for human beings in any capitalist country at present, in contrast to the schemes at present in operation in the Soviet Union.

Translated by R. E. HAMMOND

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